

# VET09

## Understanding Susceptibility Test Data as a Component of Antimicrobial Stewardship in Veterinary Settings

This report provides veterinarians with the information needed to successfully acquire and interpret antimicrobial susceptibility test results. It promotes common understanding between the veterinarian and the veterinary microbiology laboratory by providing example culture and susceptibility reports and animal species-specific guidance on applying breakpoints to interpret susceptibility test results.

A CLSI report for global application.

# Clinical and Laboratory Standards Institute

*Setting the standard for quality in medical laboratory testing around the world.*

The Clinical and Laboratory Standards Institute (CLSI) is a not-for-profit membership organization that brings together the varied perspectives and expertise of the worldwide laboratory community for the advancement of a common cause: to foster excellence in laboratory medicine by developing and implementing medical laboratory standards and guidelines that help laboratories fulfill their responsibilities with efficiency, effectiveness, and global applicability.

## Consensus Process

Consensus—the substantial agreement by materially affected, competent, and interested parties—is core to the development of all CLSI documents. It does not always connote unanimous agreement but does mean that the participants in the development of a consensus document have considered and resolved all relevant objections and accept the resulting agreement.

## Commenting on Documents

CLSI documents undergo periodic evaluation and modification to keep pace with advances in technologies, procedures, methods, and protocols affecting the laboratory or health care.

CLSI's consensus process depends on experts who volunteer to serve as contributing authors and/or as participants in the reviewing and commenting process. At the end of each comment period, the committee that developed the document is obligated to review all comments, respond in writing to all substantive comments, and revise the draft document as appropriate.

Comments on published CLSI documents are equally essential and may be submitted by anyone, at any time, on any document. All comments are managed according to the consensus process by a committee of experts.

## Appeal Process

When it is believed that an objection has not been adequately considered and responded to, the process for appeal, documented in the CLSI *Standards Development Policies and Processes*, is followed.

All comments and responses submitted on draft and published documents are retained on file at CLSI and are available upon request.

## Get Involved—Volunteer!

Do you use CLSI documents in your workplace? Do you see room for improvement? Would you like to get involved in the revision process? Or maybe you see a need to develop a new document for an emerging technology? CLSI wants to hear from you. We are always looking for volunteers. By donating your time and talents to improve the standards that affect your own work, you will play an active role in improving public health across the globe.

For additional information on committee participation or to submit comments, contact CLSI.

Clinical and Laboratory Standards Institute  
950 West Valley Road, Suite 2500  
Wayne, PA 19087 USA  
P: +1.610.688.0100  
F: +1.610.688.0700  
[www.clsi.org](http://www.clsi.org)  
[standard@cls.org](mailto:standard@cls.org)

This is a preview. [Click here to purchase the full publication.](#)

# Understanding Susceptibility Test Data as a Component of Antimicrobial Stewardship in Veterinary Settings

Virginia R. Fajt, DVM, PhD, DACVCP  
Claire R. Burbick, DVM, PhD, DACVM  
Sara Lawhon, DVM, DACVM  
Eden Bermingham, DVM, MS, DACVCP  
Robert Bowden, BS  
Erin Frey, DVM, DACVPM  
Ronette Gehring, BVSc, DACVCP  
K. Fred Gingrich II, DVM  
Merran Govendir, PhD, BVSc, FHERDSA, MANZCVSc  
Beth N. Harris, MS, PhD

Cory Langston, DVM, PhD  
Sakurako Marchand, MT  
Ron A. Miller, MS, PhD  
Mark G. Papich, DVM, MS  
Pierre Rouppert  
Stefan Schwarz, DVM  
Michael T. Sweeney, MS  
Anil J. Thachil, BVSc, MVSc, PhD, DACVM  
Jeffrey L. Watts, PhD, RM(NRCM), M(ASCP)

## Abstract

Clinical and Laboratory Standards Institute report VET09—*Understanding Susceptibility Test Data as a Component of Antimicrobial Stewardship in Veterinary Settings* discusses antimicrobial susceptibility testing (AST) that provides important, clinically relevant information to the submitting veterinarian if the veterinarian understands how the testing is performed and how the results can be interpreted. This report provides veterinarians background information about laboratory processes, including how AST is performed, reasons for AST not being performed, and how AST results are assessed by the laboratory. It also describes the reasons for varying degrees of confidence in applying breakpoints for interpreting AST results, which will empower veterinarians as they make decisions about the use of antimicrobial agents to treat bacterial disease in animals.

This report gives an overview of some of the factors that affect antimicrobial drug selection in animals, including principles of antimicrobial pharmacology, how bacterial species identification affects AST results interpretation, and the veterinarian's role in ensuring AST results are accurate and useful. By providing example susceptibility test reports with callout boxes, important facets of laboratory reports with AST results are highlighted to aid the veterinarian in maximizing the data.

This report has separate chapters for animal species—specific guidance on how to interpret AST data for dogs, cats, horses, cattle, pigs, and fish, and uniquely, it provides evidence-based appraisals of confidence in the AST data reported by laboratories. This guidance can be also used by laboratories to select appropriate breakpoints for assigning interpretive categories and to aid client veterinarians in interpreting their data.

Clinical and Laboratory Standards Institute (CLSI). *Understanding Susceptibility Test Data as a Component of Antimicrobial Stewardship in Veterinary Settings*. 1st ed. CLSI report VET09 (ISBN 978-1-68440-050-8 [Print]; ISBN 978-1-68440-051-5 [Electronic]). Clinical and Laboratory Standards Institute, 950 West Valley Road, Suite 2500, Wayne, Pennsylvania 19087 USA, 2019.

The Clinical and Laboratory Standards Institute consensus process, which is the mechanism for moving a document through two or more levels of review by the health care community, is an ongoing process. Users should expect revised editions of any given document. Because rapid changes in technology may affect the procedures, methods, and protocols in a standard or guideline, users should replace outdated editions with the current editions of CLSI documents. Current editions are listed in the CLSI catalog and posted on our website at [www.clsi.org](http://www.clsi.org).

**If you or your organization is not a member and would like to become one, or to request a copy of the catalog, contact us at:**

**P:** +1.610.688.0100 **F:** +1.610.688.0700 **E:** [customerservice@clsi.org](mailto:customerservice@clsi.org) **W:** [www.clsi.org](http://www.clsi.org)



This is a preview. [Click here to purchase the full publication.](#)

Copyright ©2019 Clinical and Laboratory Standards Institute. Except as stated below, any reproduction of content from a CLSI copyrighted standard, guideline, derivative product, or other material requires express written consent from CLSI. All rights reserved. Interested parties may send permission requests to [permissions@clsi.org](mailto:permissions@clsi.org).

CLSI hereby grants permission to each individual member or purchaser to make a single reproduction of this publication for use in its laboratory procedures manual at a single site. To request permission to use this publication in any other manner, e-mail [permissions@clsi.org](mailto:permissions@clsi.org).

## Suggested Citation

CLSI. *Understanding Susceptibility Test Data as a Component of Antimicrobial Stewardship in Veterinary Settings*. 1st ed. CLSI report VET09. Wayne, PA: Clinical and Laboratory Standards Institute; 2019.

ISBN 978-1-68440-050-8 (Print)

ISBN 978-1-68440-051-5 (Electronic)

ISSN 1558-6502 (Print)

ISSN 2162-2914 (Electronic)

Volume 39, Number 8

## Committee Membership

### Document Development Committee on Understanding AST Data in Veterinary Settings

**Virginia R. Fajt, DVM, PhD, DACVCP**  
**Chairholder**  
**Texas A & M University**  
**USA**

**Claire R. Burbick, DVM, PhD, DACVM**  
**Vice-Chairholder**  
**Washington State University**  
**USA**

**Sara Lawhon, DVM, DACVM**  
**Committee Secretary**  
**Texas A & M University**  
**USA**

Eden Bermingham, DVM, MS, DACVCP  
FDA Center for Veterinary Medicine  
USA

Erin Frey, DVM, DACVPM  
College of Veterinary Medicine,  
North Carolina State University  
USA

Ronette Gehring, BVSc, DACVCP  
Universiteit Utrecht  
Netherlands

K. Fred Gingrich II, DVM  
American Association of Bovine  
Practitioners  
USA

Beth N. Harris, MS, PhD  
USDA-APHIS-Veterinary Services-  
National Veterinary Services  
Laboratories  
USA

Sakurako Marchand, MT  
bioMérieux, Inc.  
France

Jeffrey L. Watts, PhD, RM(NRCM),  
M(ASCP)  
Zoetis  
USA

### Subcommittee on Veterinary Antimicrobial Susceptibility Testing

**Brian V. Lubbers, DVM, PhD, DACVCP**  
**Chairholder**  
**Kansas State Veterinary Diagnostic**  
**Laboratory**  
**USA**

**Mark G. Papich, DVM, MS**  
**Vice-Chairholder**  
**College of Veterinary Medicine,**  
**North Carolina State University**  
**USA**

**Lacie Johansen, BS**  
**Committee Secretary**  
**Zoetis**  
**USA**

Dubrasca V. Diaz-Campos, DVM, PhD  
College of Veterinary Medicine,  
Veterinary Medical Center,  
The Ohio State University  
USA

Mark Fielder, PhD  
School of Life Science,  
Kingston University London  
United Kingdom

Cory Langston, DVM, PhD  
Mississippi State University  
USA

Xian-Zhi Li, PhD  
Health Canada Veterinary Drugs  
Directorate  
Canada

Sakurako Marchand, MT  
bioMérieux, Inc.  
France

Marilyn N. Martinez, PhD  
FDA Center for Veterinary Medicine  
USA

Ian Morrissey, PhD  
IHMA Europe Sarl  
Switzerland

Thomas R. Shryock, PhD  
Antimicrobial Consultants, LLC  
USA

Shabbir Simjee, MSc, PhD  
Elanco Animal Health  
United Kingdom

Virginia Sinnott-Stutzman, DVM,  
DACVECC  
Angell Animal Medical Center  
(MSPCA)  
USA

Michael T. Sweeney, MS  
Zoetis  
USA

Darren Trott, PhD  
School of Animal and Veterinary  
Sciences, The University of Adelaide  
Australia

## Staff

Clinical and Laboratory Standards  
Institute  
USA

Lori T. Moon, MS, MT(ASCP)  
*Project Manager*

Megan L. Tertel, MA, ELS  
*Editorial Manager*

Catherine E.M. Jenkins  
*Editor*

Kristy L. Leirer, MS  
*Editor*

Laura Martin  
*Editor*

## Acknowledgment

---

CLSI, the Subcommittee on Veterinary Antimicrobial Susceptibility Testing, and the Document Development Committee on Understanding AST Data in Veterinary Settings gratefully acknowledge the following volunteers for their important contributions to the development of this report:

Robert Bowden, BS  
Tufts University Sackler  
School of Graduate Biomedical  
Sciences – Student  
USA

Merran Govendir, PhD, BVSc,  
FHERDSA, MANZCVSc  
The University of Sydney  
Australia

Cory Langston, DVM, PhD  
Mississippi State University  
USA

Ron A. Miller, MS, PhD  
FDA Center for Veterinary Medicine  
USA

Mark G. Papich, DVM, MS  
College of Veterinary Medicine,  
North Carolina State University  
USA

Pierre Rouppert  
bioMérieux, Inc.  
France

Stefan Schwarz, DVM  
Freie Universität Berlin  
Germany

Michael T. Sweeney, MS  
Zoetis  
USA

Anil J. Thachil, BVSc, MVSc,  
PhD, DACVM  
Cornell University  
USA

# Contents

Abstract	i
Committee Membership	iii
Foreword	ix
<b>Chapter 1: Introduction</b>	<b>1</b>
1.1 Scope	2
1.2 Background	3
1.3 Terminology	4
<b>Chapter 2: Overview of Factors Affecting Antimicrobial Agent Selection in Animals</b>	<b>9</b>
2.1 General Principles of Pharmacological Relationships in Antimicrobial Therapy	10
2.2 The Importance of the Animal Species In Antimicrobial Susceptibility Testing Data Interpretation	20
2.3 Potential Effects of Bacterial Species Similarities and Differences on Interpretation of Antimicrobial Susceptibility Testing Data	23
2.4 Important Regulatory and Legal Aspects of Antimicrobial Agent Selection in Animals	27
<b>Chapter 3: Antimicrobial Susceptibility Testing Process Overview</b>	<b>29</b>
3.1 Process Flow Charts	30
3.2 Antimicrobial Agents Selected for Primary Testing and Reporting	33
3.3 Antimicrobial Agents Excluded From Antimicrobial Susceptibility Test Reports	34
<b>Chapter 4: Typical Antimicrobial Susceptibility Test Reports</b>	<b>37</b>
4.1 Basic Information Documented in Laboratory Antimicrobial Susceptibility Test Reports	38
4.2 Example Laboratory Antimicrobial Susceptibility Test Reports	42
<b>Chapter 5: Canine-Specific and Other Breakpoints and Factors Affecting Antimicrobial Susceptibility Testing Result Interpretations for Dogs</b>	<b>49</b>
5.1 Confidence in Applicability of Breakpoints for Interpreting Antimicrobial Susceptibility Testing Results for Dogs	50
5.2 Approved Canine-Specific Breakpoint Dosage Regimens and Tissue Infection Sites	50
5.3 Applying Canine-Specific Breakpoints to Other Bacteria in Dogs	53
5.4 Applying Canine-Specific Breakpoints to Other Infection Sites in Dogs	54
5.5 Applying Canine-Specific Breakpoints to Other Doses, Routes, Frequencies, or Durations of Therapy	54
5.6 Applying Human Breakpoints for Interpreting Antimicrobial Susceptibility Testing Results for Dogs	55

# Contents (Continued)

**Chapter 6: Feline-Specific and Other Breakpoints and Factors Affecting Antimicrobial Susceptibility Testing Result Interpretations for Cats**

59

6.1 Confidence in Applicability of Breakpoints for Interpreting Antimicrobial Susceptibility Testing Results for Cats

60

6.2 Approved Feline-Specific Breakpoint Dosage Regimens and Tissue Infection Sites.

61

6.3 Applying Feline-Specific Breakpoints to Other Bacteria in Cats

62

6.4 Applying Feline-Specific Breakpoints to Other Infection Sites in Cats.

63

6.5 Applying Feline-Specific Breakpoints to Other Doses, Routes, Frequencies, or Durations of Therapy

63

6.6 Applying Human or Other Species' Breakpoints for Interpreting Antimicrobial Susceptibility Testing Results for Cats

64

**Chapter 7: Equine-Specific and Other Breakpoints and Factors Affecting Antimicrobial Susceptibility Testing Result Interpretations for Horses**

69

7.1 Confidence in Applicability of Breakpoints for Interpreting Antimicrobial Susceptibility Testing Results for Horses.

70

7.2 Approved Equine-Specific Breakpoint Dosage Regimens and Tissue Infection Sites

70

7.3 Applying Equine-Specific Breakpoints to Other Bacteria in Horses.

73

7.4 Applying Equine-Specific Breakpoints to Other Infection Sites in Horses

75

7.5 Applying Equine-Specific Breakpoints to Other Doses, Routes, Frequencies, or Durations of Therapy

75

7.6 Applying Human Breakpoints for Interpreting Antimicrobial Susceptibility Testing Results for Horses

75

**Chapter 8: Bovine-Specific and Other Breakpoints and Factors Affecting Antimicrobial Susceptibility Testing Result Interpretations for Cattle**

79

8.1 Confidence in Applicability of Breakpoints for Interpreting Antimicrobial Susceptibility Testing Results for Cattle.

80

8.2 Approved Bovine-Specific Breakpoint Dosage Regimens and Tissue Infection Sites.

80

8.3 Applying Bovine-Specific Breakpoints to Other Bacteria in Cattle

84

8.4 Applying Bovine-Specific Breakpoints to Other Infection Sites in Cattle

85

8.5 Applying Bovine-Specific Breakpoints to Other Doses, Routes, Frequencies, or Durations of Therapy

85

8.6 Applying Human Breakpoints for Interpreting Antimicrobial Susceptibility Testing Results for Cattle.

85

8.7 Considerations for Antimicrobial Susceptibility Testing Result Interpretations for Bovine Mastitis Pathogens.

86



## Contents (Continued)

<b>Chapter 9: Porcine-Specific and Other Breakpoints and Factors Affecting Antimicrobial Susceptibility Testing Result Interpretations for Pigs</b>	<b>89</b>
9.1 Confidence in Applicability of Breakpoints for Interpreting Antimicrobial Susceptibility Testing Results for Pigs	90
9.2 Approved Porcine-Specific Breakpoint Dosage Regimens and Tissue Infection Sites	90
9.3 Applying Porcine-Specific Breakpoints to Other Bacteria in Pigs	93
9.4 Applying Porcine-Specific Breakpoints to Other Infection Sites in Pigs	94
9.5 Applying Porcine-Specific Breakpoints to Other Doses, Routes, Frequencies, or Durations of Therapy	94
9.6 Applying Human Breakpoints for Interpreting Antimicrobial Susceptibility Testing Results for Pigs	95
<b>Chapter 10: Fish-Specific Breakpoints, Epidemiological Cutoff Values, and Factors Affecting Antimicrobial Susceptibility Testing Result Interpretations for Fish</b>	<b>97</b>
10.1 Confidence in Applicability of Breakpoints for Interpreting Fish Antimicrobial Susceptibility Testing Results	98
10.2 Approved Fish-Specific Breakpoint Dosage Regimens and Tissue Infection Sites	99
10.3 Applying Fish-Specific Breakpoints to Other Bacteria in Fish	100
10.4 Applying Fish-Specific Breakpoints to Other Infection Sites in Fish	100
10.5 Applying Fish-Specific Breakpoints to Other Doses, Routes, Frequencies, or Durations of Therapy	101
10.6 Applying Human or Other Species' Breakpoints for Interpreting Antimicrobial Susceptibility Testing Results for Fish	101
<b>Chapter 11: Conclusion</b>	<b>103</b>
<b>Chapter 12: Supplemental Information</b>	<b>105</b>
<b>References</b>	106
<b>Appendix A.</b> CLSI-Approved Canine-Specific Breakpoints	112
<b>Appendix B.</b> CLSI-Approved Feline-Specific Breakpoints	118
<b>Appendix C.</b> CLSI-Approved Equine-Specific Breakpoints	122
<b>Appendix D.</b> CLSI-Approved Bovine-Specific Breakpoints	126
<b>Appendix E.</b> CLSI-Approved Porcine-Specific Breakpoints	130
<b>The Quality Management System Approach</b>	132
<b>Related CLSI Reference Materials</b>	134

This page is intentionally left blank.

## Foreword

This report is designed to provide veterinarians and other stakeholders in veterinary diagnostics with key information needed to appropriately interpret antimicrobial susceptibility testing (AST) data for application to clinical decision-making. This report can therefore be read from beginning to end for a comprehensive overview by animal species, bacterial type, and antimicrobial agents in the context of AST. However, each chapter is also designed to provide stand-alone information, so the report can be sampled as needed.

This report includes general guidance on how to apply pharmacological principles to selection and use of antimicrobial agents and how to get the best information from the laboratory, starting with submitting an animal specimen for culture through receiving the laboratory report with AST results. Basic components of a laboratory report and specific examples with AST results are included with commentary on the information reported, as well as different presentations that clinicians may receive from different laboratories. There is also an overview of regulatory and legal considerations for antimicrobial agents. Finally, separate chapters are included that focus on AST results interpretations applied to different animal species: dogs, cats, horses, cattle, pigs, and fish.

Some unique information included in this report is not available anywhere else, including recommendations on extrapolating from:

- One infection site to another
  - For example, whether a breakpoint established for *Escherichia coli* from skin and soft-tissue infections in dogs can be applied to *E. coli* isolated from the lungs
- One bacterial species to another
  - For example, whether a breakpoint established for *E. coli* can be applied to *Klebsiella pneumoniae*
- One animal species to another
  - For example, whether it is reasonable to apply canine breakpoints to bacterial isolates from cats

**NOTE:** The content of this report is supported by the CLSI consensus process and does not necessarily reflect the views of any single individual or organization.



### NOTE:

Each chapter in this report is designed to provide stand-alone information.

### KEY WORDS

**Antimicrobial stewardship**

**Antimicrobial susceptibility testing**

**Breakpoints**

**Interpretive categories**

**Laboratory**

**Reporting**

**Species-specific breakpoints**

**Veterinary**